THE INFLUENCE OF FIBROUS PERIODONTAL LIGAMENT ON TOOTH MOVEMENT AND LOAD TRANSFER: A 3D FINITE ELEMENT STUDY

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Introduction

The periodontal ligament (PDL) is a soft, fibrous, connective tissue that joins the tooth root to the tooth socket and thus plays an important role in the transmission of masticatory and orthodontic loads from the teeth to the surrounding bone. Most finite element (FE) models of the masticatory apparatus idealise the PDL as a layer of solid, homogeneous and isotropic material. Although some authors have attempted to represent its material properties more accurately, few have attempted to include its fibre-reinforced structure [e.g. Provatidis, 2000; Meyer *et al*, 2010]. So far, those models which include the PDL fibres have only investigated their effect under low loads, typical of orthodontic tooth movement. The aim of this study is to investigate the significance of including the fibres of the PDL in FE models when applying functional occlusal loads.

Methods

An idealised three-dimensional single tooth FE model was developed and is shown in figure 1. A static 500 N occlusal load was applied to the centre of the top of the tooth to represent a maximal human bite force [O'Connor *et al*, 2005]. Three different representations of the PDL were tested: no PDL, solid PDL and fibrous PDL. The fibrous PDL model consisted of the solid model with the addition of PDL fibres as shown in figure 1. For each model, vertical tooth displacement was calculated and the strain distributions in the alveolar and trabecular bone were compared.

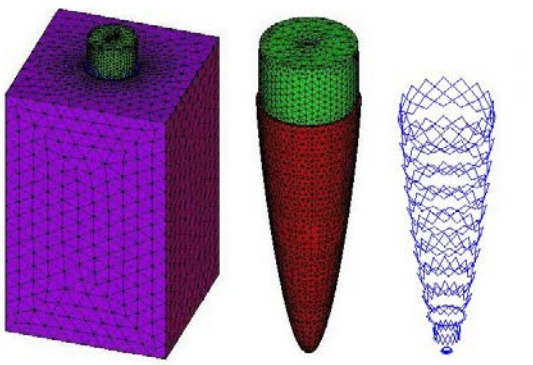

Figure 1: Left to right: the whole 3D single tooth model, the tooth and PDL, and the PDL fibres only.

Results

Tooth displacement was much larger when the PDL was included (Table 1). Results from the solid PDL model were unrealistic whereas adding fibres to the model brought the results consistent with those reported in previous experimental studies [Borák *et al*, 2011]. Similar results to those of the fibrous PDL model could be obtained from the solid PDL model by increasing Young's modulus of the solid PDL material. Including PDL fibres also had an influence on the magnitude and distribution of strain, although this influence decreased further away from the alveolar bone.

Model	Vertical Tooth Displacement* (mm)
No PDL	0.000080
Solid PDL	0.990690
Fibrous PDL	0.070300

*as defined by Katona and Qian [2001]

Table 1: Vertical tooth displacement under the application of a 500 N occlusal load.

Discussion

Our results highlight the importance of the PDL for tooth mobility and preventing high stresses around the alveolar bone. Modelling PDL as a fibrous structure requires additional time and effort during model building, but is justified by the fact that it produces more realistic results. For a simple vertical occlusal force, increasing the modulus of the PDL generates similar results, although whether this is still the case for more complex loading schemes needs further investigation.

References

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